Vectors of the Papaya Mosaic Virus in Hawaii[1]

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Vector range studies have been conducted in Bombay, India (Capoor and Varma, 1958) and Puerto Rico (Schaefers, 1969) with papaya mosaic which is similar or closely related to the one in Hawaii. Several aphids were found to be vectors both in Bombay and Puerto Rico. In Hawaii, the green peach aphid, *Myzus persicae* (Sulzer), has been used routinely for the transmission of the papaya mosaic virus (Namba and Kawanishi, 1966). No other aphid species has been tested although several species have been recorded on papaya in Hawaii (Zimmerman, 1948).

In the present study the aphid species heretofore recorded on papaya in Hawaii—*Hyperomyzus lactucae* (L.), *Aphis gossypii* Glover, *Rhopalosiphum maidis* (Fitch), *Aphis craccivora* Koch, and *Macrosiphum euphorbiae* (Thomas)—were tested as vectors. Two other species—*Aphis middletonii* Thomas and *Myzus circumflexus* (Buckton)—have been recorded on papaya in Hawaii, however, we were not able to collect them. Two species of mites—the carmine spider mite, *Tetranychus cinnabarinus* (Boisduval) and the broad mite, *Polyphagotarsonemus latus* (Banks)—which are major pests of papaya in Hawaii were also tested.

Materials and Methods

The virus-source plants used in this study were subinoculations from a diseased papaya plant obtained from the Plant Pathology Department, Hawaii Agricultural Experiment Station.

The test plants used were watermelon, *Citrullus vulgaris* Schrader var. Black Chilean; cucumber, *Cucumis sativus* L. var. Colorado Long; and papaya, *Carica papaya* L. var. Solo. They were grown in sterilized soil in 3 in plastic pots. The cucurbits were used in the cotyledon stage and the papaya in the 3–4 leaf stage.

R. maidis was collected on corn, *Zea mays* L.; *M. euphorbiae* on sow thistle, *Sonchus oleraceus* L.; *Aphis gossypii* on cucumber; *A. craccivora* on yard-long bean, *Vigna sesquipedalis* W. F. Wight and string beans, *Phaseolus vulgaris* L.; *H. lactucae* on sow thistle; *T. cinnabarinus* on string beans; and *P. latus* on papaya. Each species was maintained in the greenhouse on the same host plant species on which it was collected.

The aphids were held without food in empty 1 dram glass vials for more than 30 min. prior to the transmission tests. They were then placed

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onto a leaf of the virus source plant and allowed a virus acquisition access period of about 3 min. then transferred immediately to healthy watermelon test plants, 10 aphids per plants. In the case of *M. euphorbiae* only 5 aphids were used per plant. After about an hour on the test plants the aphids were killed with nicotine sulphate spray and the plants were placed in an insect-proof greenhouse to await manifestation of symptoms. With each test a check series was conducted simultaneously with the known vector *M. persicae*. Transmission occurred in each of the check series.

Two methods of transmission were used with the carmine spider mite. In one method numerous mites from the stock colony were placed on potted diseased papaya and watermelon plants. One each of the mite infested diseased plants was placed in a water pan in a cage and the two diseased plants were surrounded with two each of cucumber, watermelon, and papaya test plants. The test plants were left with the diseased plants for one week. During this period, although the test plants and the virus source plants were not touching, the mites moved readily from the virus source plants to the test plants. At the end of the test access period the mites were brushed off and the test plants were placed in the greenhouse for incubation.

In the other method the carmine spider mites were picked off singly with a fine needle from the stock colony plant and transferred to the virus source plant. There they were allowed a watched and timed feeding of about 1 min. after which they were immediately placed on a test plant, 5 mites per test plant. After about an hour the mites were brushed off the test plants and the plants were placed in the greenhouse for incubation.

With the broad mite watched and timed acquisition feeding was not feasible. Instead the broad mites were colonized on a diseased papaya plant and when the mites became numerous on a leaf, the leaf was detached and hung closely over a healthy papaya test plant. When the leaf wilted the mites migrated to the healthy plants. After about 2 days on the test plants the mites were brushed off under a dissecting microscope and the plants were placed in the greenhouse for incubation.

Results and Discussion

The results of the transmission tests with the aphid species are presented in Table 1. No transmission occurred with *H. lactucae*. All other species, including *M. persicae* which was used as the check species, were transmitters of the papaya mosaic virus.

No transmission occurred with the carmine spider mite or the broad mite (Table 2).

Table 3 is a complilation of the data from the vector range studies of the papaya mosaic virus of Capoor and Varma (1958), Schaefers (1969), and the present work. A total of 18 species of aphids was investigated by the three studies, however, only six species were included by more

TABLE 1. *Transmission of the papaya mosaic virus in Hawaii by various aphid species. Watermelon was used as the test plant.*

Aphid species	*No. plants infected/No. plants tested*
Rhopalosiphum maidis	53/100
*Macrosiphum euphorbiae**	20/100
Hyperomyzus lactucae	0/53
Aphis gossypii	13/16
A. craccivora	2/30

*5 aphids per test plant; all other species, 10 per test plant.

TABLE 2. *Summary of unsuccessful attempts to transmit the papaya mosaic virus with the carmine spider mite and the broad mite.*

Species	*Method*	*Virus-source plant*	*Test plant*	*No. test plant*
T. cinnabarinus	caged	papaya	papaya	24
T. cinnabarinus	caged	papaya	watermelon	24
T. cinnabarinus	caged	papaya	cucumber	24
T. cinnabarinus	caged	watermelon	papaya	24
T. cinnabarinus	caged	watermelon	watermelon	24
T. cinnabarinus	caged	watermelon	cucumber	24
T. cinnabarinus	watched & timed	papaya	papaya	25
T. cinnabarinus	watched & timed	papaya	watermelon	25
T. cinnabarinus	watched & timed	watermelon	watermelon	25
P. latus	caged	papaya	papaya	50

TABLE 3. *Aphid vector range studies of the papaya mosaic virus in Bombay, India (Capoor and Varma, 1958), Puerto Rico (Schaefers, 1969), and Hawaii.*

Aphid species tested	*Bombay*	*Puerto Rico*	*Hawaii*
Aphis nerii Boyer de Fonscolombe	0	+	
A. gossypii Glover	+	+	+
A. spiraecola Patch		+	
A. craccivora Koch	+	0	+
A. illinoisensis Shimmer		0	
A. malvae Koch	+		
Aphis sp.	+		
Dactynotus ambrosiae (Thomas)		0	
Hyperomyzus lactucae (L.)		0	0
Myzus persicae (Sulzer)	+	+	+
Rhopalosiphum maidis (Fitch)		0	+
R. nymphaeae (L.)		0	
Sipha flava (Forbes)		0	
Toxoptera aurantiae (B. de F.)		0	
T. citricidus Kirkaldy	0		
Pentalonia nigronervosa Coquerel	0		
Macrosiphum euphorbiae (Thomas)			+
M. sonchi L.	+		

than one study. Discrepancies occurred with 3 species and agreement with the same number of species. Transmission occurred with *A. nerii* in the study of Schaefers but not in that of Capoor and Varma. In the present work transmission occurred with *R. maidis* but not in the study of Schaefers. With *A. craccivora* transmission occurred in the study of Capoor and Varma and the present study but not in that of Schaefers. With *A. gossypii* and *M. persicae* transmission occurred in all three studies. With *H. lactucae* there was agreement in the study of Schaefers and the present work in that no transmission occurred in both.

It seems, in view of the vector range studies, that the papaya mosaic of Bombay and Hawaii may be different from the one in Puerto Rico. However, unless a wider range of vectors is tested under a standardized procedure, the determination would be inconclusive. It is especially important that the virus acquisition access time be standardized. It is known that with non-persistent viruses such as the papaya mosaic virus, acquistition probes of more than a minute or two decrease the probability of transmission. In Capoor and Varma's study the acquisition access period was from 2–8 hours; in Schaefers from 5–60 min. and in the present study 3 min. The differences in the acquisition access period could have contributed to the discrepancies among the studies. With the long access periods it is possible that the test aphids were in prolonged probe when they were picked off to be transferred to the test plants.

The non-transmission of the papaya mosaic virus by the two mite species was somewhat expected since mite vectors of plant viruses are known only from a different family—Eriophyidae. There have been reports of transmission by mites other than eriophyids but careful efforts to duplicate the results have been unsuccessful (Oldfield, 1970). Nevertheless, in the present work the two species of mites were tested because they are very common on papaya in Hawaii and it was thought that transmission might occur if the mites were allowed short, watched and timed virus acquisition probes.

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